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Yields and protein content of two cowpea varieties grown under different production practices in Limpopo province, South Africa

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A three-factorial field experiment was carried out at the University of Limpopo experimental Research farm during two planting seasons (2005/06 and 2006/07) to examine the effect of cowpea-leaf removal on cowpea performance. Three treatment factors namely cowpea varieties (Pan 311 and Red Caloona), cropping systems (sole and intercropping) and cowpea-leaf pruning regimes (pruned and un-pruned) were combined and arranged in a randomized complete block design (RCBD). Sole cowpea and sweet corn treatments were included and all treatments replicated four times. Fully expanded cowpea leaves on all cowpea plants in the two middle rows were harvested once at seven weeks after seed sowing prior to flowering. Growth and yield component data were collected from component crops while the protein content of harvested leaves and green pods as well as those of grains and the fodders at harvest were determined. The results of the study revealed that cowpea leaf protein content ranged from 24.1 to 28.1% and 26.0 to 30.7% for Red Caloona and Pan 311, respectively. The protein content of green cowpea pods obtained from Pan 311 cowpea variety ranged from 18.8 to 25.1% while that of Red Caloona varied between 17.9 and 20.7%. Similarly, the protein content of the fodder obtained after grain harvest varied between 9.3 and 9.4% and 9.9 and 12.3%, respectively for Pan 311 and Red Caloona during the two seasons. The protein content of cowpea grain obtained from intercropped plots (23.7 to 26.3%) was similar to that from sole plots (23.7 to 25.7%). In 2005/06, grain yield was 1704 kg ha^{-1} and 1480 kg ha^{-1} respectively for Pan 311 and Red Caloona while 1291 and 512 kg ha^{-1} were obtained for Pan 311and Red Caloona, respectively in 2006/07. There was a significant season x varietal effects on pod and seed protein content. These results reveal that Pan 311 would be better suited for both vegetable and grain production purposes for human consumption while Red Caloona would better serve as a fodder crop for animal production. The results also show that neither cropping system nor cowpea leaf pruning did have consequential effects on the nutritional value of cowpea plant parts and grains.

Key words: Cropping systems, leaf pruning, cowpea protein, grain yield, dryland farming.

INTRODUCTION

Cowpea (*Vigna unguiculata* [L.] Walp.) is an important grain and fodder legume crop grown in many parts of the world. It is an important grain crop that contains about 25% protein and thus represents cheaper plant-protein source than meat and fish particularly for resource-poor people. It is an extremely valuable crop that is also rich in vitamins and minerals (Bressani, 1985). Cowpea is used at all stages of its growth including as a vegetables (Ofori and Stern, 1986). In many parts of Africa, removing young cowpea leaves for use as vegetables is a common practice (Barrett et al., 1997). Harvested tender green cowpea leaves constitute an important leafy vegetable often prepared as salad like spinach, lettuce, amaranthus

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and cabbage for direct consumption or eaten as relish along with other foods like potato and maize meals. Earlier studies have revealed that cowpea leaves contain carbohydrate whose concentration is higher in older leaves with the protein content in such older leaves comparable to that in seeds (Bubenheim et al., 1990). Few studies have revealed that removing too many young leaves from cowpea plants will impair grain yield, while removing oldest leaves increases it (Barrett et al., 1997). An earlier report by Bubenheim et al. (1990) also indicated that the total grain yield as well as seed and pod numbers per plant could be severely decreased following partial defoliation of cowpea plants. This report concluded that if cowpea is grown for grains, leaf harvesting should cease before the pods begin to expand.

Cowpea is often planted by few farmers as sole crop and also grown on marginal soils in an intercrop (binary culture) as companion crops with cereals. However, reduction in cowpea grain yields and yield component parameters in a corn-cowpea intercrop had been reported by numerous workers. Murray and Swensen (1985) reported that intercropping could be successfully used to improve yield and the efficiency of land use for several warm season food annuals. Alghali (1991) similarly noted that the number of pods per plant differs significantly among cropping systems at different locations with sole cowpea producing higher number of pods and grain yields. Furthermore, Barrett et al. (1997) reported that intercropping does not only bring about reduced seed yield but also raises the combined dry weight of seeds and leaves of the component crops by up to 18%. However, the reduction of cowpea grain yields in a corn-cowpea intercrop has been attributed to competition for nutrients, including nitrogen (Murray and Swensen, 1985) and possibly shading effects (Egli and Bruening, 2005). The shading effects of intercropping have been described as the possible factor that could reduce the number of flowers per cowpea plant, stimulate flower and pod abortion (Egli and Bruening, 2005) and ultimately impact negatively on the harvestable grain yields. Despite some of these inherent constraints the duo of intercropping as a practice and the harvesting of tender cowpea leaves as vegetables, remain dominant practices in many Africa rural, peri-urban and urban vegetable farming.

However, there is dearth of information regarding the compatibility of these practices in the face of the escalating effects of climate change, greenhouse gases, global warming, drought, rising agricultural input costs and the apparent global decline in food production. An access to such vital information will constitute an essential impetus towards arresting the present negative effects of the world food crises, increasing poverty and hunger. This study would possibly result in increased production and better access to cheap nutrients and mineral-rich vegetables and thus guaranteeing improved nutrition, household food security and healthy living conditions.

The objective of the study was therefore to determine the effect of cowpea leaf-removal on the protein content of the different plant parts and grain yield under sole and binary cultures.

MATERIALS AND METHODS

Description of experimental sites and its cropping history

This study was conducted at University of Limpopo experimental farm, Syferkuil (23° 85′S and 29° 67′E, Altitude 1250 m) during 2005/06 and 2006/07-summer growing seasons. The soil at the farm has a sandy loam texture, with relatively high fertility due to long history of fertilization (Mpangane et al., 2004). The area usually receives mean annual rainfall of 500 mm that is often fairly distributed over the growing period and daily temperature range of 12 to 35˚C during planting season (Mpangane et al., 2004).

Details of the trial, experimental design and field layout

The experiment consisted of two cowpea varieties (Pan 311 and Red Caloona), two cropping systems (sole and intercropping) and two leaf-pruning regimes (pruned and un-pruned) as factors. Leaf pruning was restricted only to cowpea plants. The different factors were combined to obtain eight treatment combinations, with sole sweet corn and sole cowpea plots included as control treatments. Treatments were arranged in a randomized complete block design (RCBD) and replicated four times. Cowpea seeds were sown at an intra-row spacing of 20 cm whilst intra-row spacing of 40 cm was used for sweet corn. There were six rows of each crop under sole plots and four rows of cowpea in the intercrop plots.

Agronomic practices, data collection and analyses

The results of pre-planting surface (0 - 15 cm) soil analysis from the experimental plot revealed a pH (KCl) value of 6.89, total N content of 0.08%, Bray P1 and exchangeable K content of 32 and 194 mg kg^{-1}, respectively in 2005/06. Based on this result, 20 N kg ha^{-1} urea fertilizers was broadcasted on the experimental plots prior to planting while 40 N kg ha^{-1} was topdressed in sweet corn plots at four weeks after planting using side placements. The sweet corn plants were uniformly thinned to two plants per stand at three weeks after emergence during both planting seasons. Mechanical weed control was also regularly done first at three weeks after plant emergence and subsequently once during the vegetative stage and close to crop maturity. Cowpea plants were fully protected against aphid infestation and flower sucking insects through regular spray of insecticide (Malathion 50 EC). The trial regularly received 12 - 15 mm irrigation with observable signs of water stress on sweet corn during both seasons.

Fully expanded leaves were harvested once on all cowpea plants from the two middle rows of each plot at seven weeks after planting. Three fully developed green pods were randomly harvested from five cowpea plants in each plot, during mid-reproductive stage. The harvested leaves and green pods were oven-dried at 65°C to a constant weight and ground for total N -content determination. The total nitrogen content in the different cowpea plant parts was determined using the Kjeldahl digestion procedure (Page et al., 1982) while the percent protein content was thereafter estimated from the Kjeldahl Total nitrogen determination (crude protein % = Total N % x 6.25).

At full maturity, the number of dried cowpea pods per plant were harvested, counted and recorded per plot. Similarly, cowpea fodder was harvested and thereafter, pods were shelled, seed weighed

Table 1. Percent protein content of leaves of two cowpea varieties harvested prior to flowering.

Treatments	2005/06	2006/07	Mean (across season)
Cropping (C)			
Intercrop	24.66	29.12	26.89
Sole	25.47	29.64	27.56
SE	1.2	0.5	0.7
CV%	4.9	1.7	2.6
(Prob.)	ns	ns	
Variety (V)			
Pan 311	25.98	30.68	28.33
Red Caloona	24.14	28.08	26.11
SE	1.2	0.5	0.7
CV%	4.9	1.7	2.6
(Prob.)	ns	0.01	

ns = not significant, SE = standard error, CV = coefficient of variation

and recorded for yield determination. Data generated were subjected to analysis of variance (ANOVA) using the Stat-graphics™ plus version 5.0. Differences between treatment means were tested at 5% probability level and means separated using standard error and least significant difference (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Protein content of cowpea leaves harvested prior to flowering

The protein content of cowpea leaves harvested prior to flowering is contained in Table 1. In 2006/07, the mean leaf protein content of the two cowpea varieties differed significantly ($P < 0.05$), being generally higher in Pan 311 (30.7%) than Red Caloona. This might be attributed to the structure of the leaf canopy, which enhanced maximum exposure of leaves to sun radiation for protracted period in Red Caloona. According to Thornley (2002), the factor influencing leaf nutrient content also includes the position of leaf tissue. According to Vu et al. (2006), UV-B radiation of 1.36 and 1.83 UV-BSEU can lead to decrease in soluble protein in leaf extracts of legumes when exposed to such amount of radiation. This possibly affected photosynthesis, quality of photosynthates and protein partitioning. Cowpea leaves from sole crop plots had higher protein content of 25.5 and 29.6% during 2005/06 and 2006/07 planting seasons, respectively than those from the intercrop. This agrees with similar findings by Muhammad et al. (2006) who reported that cowpea in sole plots more crude protein were obtained than in the intercropped plots. This also agrees with findings by Saidi et al. (2007) who reported that in a maize-cowpea intercropping system, in the absence of applied P, maize becomes more competitive than cowpea in the initial stages. Significantly ($P < 0.05$) higher leaf protein content was obtained in 2006/07 than in 2005/06 possibly due to more favorable climate particularly rainfall and better irrigation or due to the residual effect of soil nutrients from previous growing season occasioned by nitrogen fixation. The protein content of cowpea leaves reported in this study is comparable to 28% value for spinach but higher than 15.4% for cabbage reported by Srisangnam et al. (2007). The implication is that resource-poor farmer can readily substitute the more expensive cabbage for a better and easily grown cowpea leaves as plant protein source for improved nutrition. It also creates an additional market and income source for cowpea producers at the early stage of the crop growth.

Protein content of cowpea green pods as affected by different treatments

The mean protein content of green pods of the two cowpea varieties obtained during the two seasons differed significantly ($P < 0.05$) with higher mean value during 2006/07 than 2005/06 (Table 2). Similarly, the protein content of green pods obtained from Pan 311 was gene-rally higher than that from Red Caloona, with a significant season x variety interaction effects ($P < 0.05$). Values obtained during the two seasons ranged between 17.3 and 25.65% depending on variety, production practices and season. These values are comparable to the range of 18.7 to 29.1% for green peas reported by Periago et al. (1996) and 9.83 to 30.9% for carrot (Singh et al., 2004). In 2006/07 season, the differences between the mean protein content of green pods obtained from Pan 311 and Red Caloona was significant. The higher values obtained in Pan 311 was probably because of its early maturity status and better nutrients uptake ability including nitrogen

Table 2. Percent protein content of green pods of two cowpea varieties harvested prior to full maturity.

Treatment	Pan 311			Red Caloona		
	2005/06	2006/07	Mean (across season)	2005/06	2006/07	Mean (across season)
Cropping system (C)						
Intercrop	18.52	25.26	21.89	18.32	20.17	19.25
Sole crop	19.17	24.91	22.04	17.57	21.30	19.44
SE	0.7	0.5	0.3	0.7	0.5	0.3
CV (%)	3.81	2.24	1.5	3.81	2.24	1.5
(Prob.)	ns	ns		ns	ns	
Leaf pruning (P)						
Pruned	18.91	24.52	21.72	17.31	20.28	18.80
Un-pruned	18.79	25.65	22.22	18.58	21.18	19.88
SE	0.7	0.5	0.3	0.7	0.5	0.3
CV (%)	3.81	2.24	1.5	3.81	2.24	1.5
(Prob.)	ns	ns		ns	ns	

(Griffin et al., 2000). Neither cropping systems nor cowpea leaf pruning during the vegetative stage had significant effect on the protein content of cowpea green pods. This agrees with similar findings by Saidi et al. (2007) who reported that harvesting leaves from cowpea plant at 5 or 7 weeks after planting does not affect leaf, green pod and stem weight and nutrient content. This indicates that Pan 311 green pods could serve as a relatively cheaper and closer substitute for green peas given the fact that cowpea is more adapted, vigorous and easier to cultivate. Hence the consumption of cowpea green pods must be encouraged in the rural poor communities for enhanced intake of protein.

Effect of the different production practices on cowpea yield component parameters

The number of pods produced per plant, total fodder production and cowpea grain yield obtained during the two seasons are contained in Table 3. Pod count per plant for the two varieties obtained at harvest differed significantly ($P < 0.05$) during both seasons, with higher counts in Red Caloona. The number of pods per plant was not significantly affected by cowpea-leaf pruning regime during 2006/07 planting season. In 2006/07, significant variety x cropping system as well as variety x cropping systems x pruning interaction ($P < 0.05$) effects were obtained on pods count. Sole cowpea plots produced higher pods counts per plant during both seasons. This agrees with previous findings by Alghali (1991), who reported significantly higher number of pods with sole cowpea than intercropped cowpea at different locations. In 2005/06, mean pod count of approximately 42 per plant was significantly higher than 35 in 2006/07 season irrespective of the variety. Though neither cropping systems nor pruning regimes had significant effect on pod count in 2005/06, sole crop plots gave higher pods than intercrop plots. The same is also true of un-pruned cowpea plants relative to pruned plants. In 2006/07, cropping system however exerted a significant effect ($P < 0.05$) on cowpea pods count obtained at harvest, with higher counts under sole plots possibly because of the absence of shading effects.

In 2005/06, fodder production for the two varieties was neither affected by cropping systems nor leaf pruning regimes. Nevertheless, the 179.8 kg ha^{-1} fodder produced by Red Caloona was higher than that of Pan 311 but being generally higher under sole cropping. The lower fodder production during 2005/06 relative to the grain yield is attributed to a sudden frost incidence witnessed during the latter part of the season that led to a considerable reduction in fodder yield. Similarly, un-pruned cowpea plots produced higher fodder than pruned plots. However in 2006/07, cowpea variety and cropping system showed significant effect ($P < 0.05$) on fodder production. Fodder production in Red Caloona was significantly higher than Pan 311 while yield from sole crop plots was also higher than in intercrop plots. Fodder yield differed significantly across the two seasons being significantly higher in 2006/07 than 2005/06 due to the frost incidence reported earlier and probably due to better management during 2006/07 season.

Mean grain yield of 1917 kg ha^{-1} from sole cowpea plot was higher than 1266 kg ha^{-1} from intercrop plot In 2005/06, even though not significant. Similarly, Pan 311 grain yield of 1704 kg ha^{-1} did not differ significantly from 1480 kg ha^{-1} of Red Caloona. In 2006/07, the difference in mean grain yield among cropping systems and cowpea variety was significant ($P < 0.05$). Grain yield of 1068 kg ha^{-1} under sole crop was significantly higher than 735 kg ha^{-1} under intercrop. Similarly, Pan 311 grain yield of 1291 kg ha^{-1} was significantly higher than 512 kg ha^{-1} for Red Caloona. Although Red Caloona had high pod

Table 3. Effect of cropping sytems and leaf pruning on yield components of two cowpea varieties.

Treatments	Number of pods per plant		Fodder production (Kg ha^{-1})		Grain yield (Kg ha^{-1})	
	2005/06	2006/07	2005/06	2006/07	2005/06	2006/07
Cropping systems (C)						
Intercrop	38.9	31.1	132.5	1373.2	1266.1	734.5
Sole	45.6	39.6	195.7	2026.9	1917.4	1067.9
SE	4	1.3	26.1	121.7	239	37
CV%	10.1	3.6	15.9	7.2	15	4.1
(Prob.)	ns	0.00	ns	0.001	ns	0.000
Variety (V)						
Pan 311	33.6	25.7	148.4	1433.6	1703.7	1290.7
Red Caloona	51.0	44.9	179.8	1966.4	1479.8	511.7
SE	4	1.3	26.1	121.7	239	37
CV%	10.1	3.6	15.9	7.2	15	4.1
(Prob.)	0.009	0.00	ns	0.006	ns	0.000
Leaf pruning (P)						
Pruned	36.4	34.4	149.6	1697.6	1581.5	926.2
Un-pruned	48.1	36.2	178.7	1702.4	1602	876.2
SE	4	1.3	26.1	121.7	239	37
CV%	10.1	3.6	15.9	7.2	15	4.1
(Prob.)	ns	ns	ns	ns	ns	ns

ns = not significant, SE = standard error, CV = coefficient of variation

count, the grain yield was lower than that of Pan 311 (Table 3). This may be attributed to poor correlation (R^2 = 0.23) between grain yield and pod count reported in this study. This is contrary to the findings by Stock et al. (1996) who reported high and positive correlation between pod count and grain yield in soybean. In both seasons, Pan 311 produced higher grain yield than Red Caloona, which is possibly attributed to the high plant population in the former at harvest. This is supported by the findings of Ball et al. (2001) who hinted that the grain yields for short growing season legume crops are increased by high population densities. The reduction in cowpea grain yield under intercrop obtained in this study agreed with previous study (Murray and Swensen, 1985) that attributed this to competition for nutrients including nitrogen and possibly shading effects. Significant ($P < 0.05$) variety x leaf pruning as well as cropping system x leaf pruning interactions on cowpea grain yield was obtained in 2006/07. The lower grain yield during 2006/07 despite the better growth conditions may be attributed to other factors that were not under the control of the experiment.

Treatment effect on the protein content of cowpea grains and fodder

In 2005/06, none of cropping system, cowpea variety and cowpea-leaf pruning regimes any significant effect on percent protein content of cowpea grains and fodder (Table 4). However, the observed marginal increase in grain and fodder protein content in 2006/07 may be attributed to better management particularly irrigation. The protein content of fodder from Red Caloona was higher than that of Pan 311. This may be attributed to the better utilization of fixed N in the former, which is a late maturing variety. This agrees with previous work reported by Cisse et al. (1995).

Neither cropping systems nor cowpea leaf pruning showed any significant effect on the percent grain protein. This agreed with earlier findings by Bubenheim et al. (1990) that the protein content in different cowpea plant parts is not suppressed by the combination of leaf and seed harvesting. In 2006/07, the percent grain protein content obtained from Red Caloona was significantly ($P < 0.05$) higher than that of Pan 311. This may be attributed to its longer growing period, which possibly promoted better utilization of soil resources including fixed N (Cisse et al., 1995). Grain protein content of cowpea grown under intercrop was higher than that under sole crop. This was possibly due to compensation for less protein that portioned to the leaves of cowpea in the intercrop plots.

Conclusion

The nutritional value of cowpea plant parts varies greatly depending on the variety. Cowpea can be used as addition to a large variety of other food crops through utilization of the three different edible plant parts, which are seeds, green pods and leaves. When cowpea is grown as a vegetable crop (that is, leaves and green pods production), it should be planted as sole crop and harvested since higher protein content of both leaves and green pods will be obtained than when intercropped with cereal

Table 4. Effect of cropping system and leaf-pruning on protein content of fodder and grain of two cowpea varieties.

Treatments	Fodder at grain harvest		Grain	
	2005/06	2006/07	2005/06	2006/07
Cropping system (C)				
Intercrop	9.8	10.5	23.7	26.3
Sole	9.6	11.2	23.7	25.7
SE	0.5	0.4	0.2	0.4
CV%	5.1	4.0	0.9	1.6
(Prob.)	ns	ns	ns	ns
Variety (V)				
Pan 311	9.4	9.3	23.8	24.7
Red Caloona	9.9	12.3	23.5	27.2
SE	0.5	0.4	0.2	0.4
CV%	5.1	4.0	0.9	1.6
(Prob.)	ns	0.000	ns	0.001
Leaf pruning (P)				
Pruned	10.2	10.7	23.7	25.6
Un-pruned	9.2	10.9	23.7	26.4
SE	0.5	0.4	0.2	0.4
CV%	5.1	4.0	0.9	1.6
(Prob.)	ns	ns	ns	ns

ns = not significant, SE = standard error, CV = coefficient of variation

crops like sweet corn. The results of this study reveal that Pan 311 is more suitable for vegetable production than Red Caloona.

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